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DESCRIPTION

FLAT TUBE AND PROCESS FOR PRODUCING HEAT EXCHANGER WITH USE OF THE FLAT TUBE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. §111(a) claiming the benefit pursuant to 35 U.S.C. §119(e)(1) of the filing data of Provisional Application No. 60/404,127 filed August 19, 2002 pursuant to 35 U.S.C. §111(b).

TECHNICAL FIELD

The present invention relates to heat exchange tubes for heat exchangers, flat tubes, for example, for use as refrigerant tubes in condensers or evaporators for motor vehicle air conditioners, as oil tubes in motor vehicle oil coolers and as water tubes in motor vehicle radiators, and a process for producing heat exchangers with use of such flat tubes.

The term "aluminum" as used herein includes aluminum alloys in addition to pure aluminum. The upper and lower sides, and left- and right-hand sides of each of the drawings will be herein referred to respectively as "upper," "lower," "left" and "right."

BACKGROUND ART

In recent years, widely used in motor vehicle air conditioners in place of conventional serpentine condensers

are condensers which comprise, as shown in FIG. 7, a pair of headers 50, 51 arranged in parallel and spaced apart from each other, parallel flat refrigerant tubes 52 made of aluminum and each joined at its opposite ends to the two headers 50, 51, corrugated aluminum fins 53 each disposed in an air flow clearance between the adjacent refrigerant tubes 52 and brazed to the adjacent tubes 52, an inlet pipe 54 connected to the upper end of peripheral wall of the first 50 of the headers, an outlet pipe 55 connected to the lower end of peripheral wall of the second 51 of the headers, a first partition 56 provided inside the first header 50 and positioned above the midportion thereof, and a second partition 57 provided inside the second header 51 and positioned below the midportion thereof, the number of refrigerant tubes 52 between the inlet pipe 54 and the first partition 56, the number of refrigerant tubes 52 between the first partition 56 and the second partition 57 and the number of refrigerant tubes 52 between the second partition 57 and the outlet pipe 55 decreasing from above downward to provide groups of channels. A refrigerant flowing into the inlet pipe 54 in a vapor phase flows zigzag through units of channel groups in the condenser before flowing out from the outlet pipe 55 in a liquid phase. The condensers of the construction described (see JP-B No. 45300/1991) are called multiflow condensers, and realize high efficiencies, lower pressure losses and supercompactness.

It is required that the refrigerant tube 52 of the condenser

described be excellent in heat exchange efficiency and have pressure resistance against the high-pressure gaseous refrigerant to be introduced thereinto. Moreover, the tube needs to be small in wall thickness and low in height so as to make the condenser compact.

JP-A No. 281373/1994 discloses various flat tubes which are excellent in heat exchange efficiency for use as such refrigerant tubes.

The above publication, FIGS. 5 to 6 and FIG. 13, discloses flat tubes each comprising an upper wall, a lower wall, a right and a left side wall interconnecting the upper and lower walls at the respective right and left side edges thereof, and a plurality of reinforcing walls interconnecting the upper and lower walls, extending longitudinally of the tube and spaced apart from one another as positioned between the right and left side walls, the tube having parallel fluid channels formed inside thereof, each of the reinforcing walls having communication holes for holding the adjacent fluid channels in communication with each other therethrough, each of the reinforcing walls being formed from a downward ridge projecting downward from the upper wall integrally therewith and an upward ridge projecting upward from the lower wall integrally therewith by brazing the two ridges to each other as positioned end-to-end. Cutouts formed in the lower edge of the downward ridge at a predetermined spacing are joined to and positioned in register with respective cutouts formed in the upper edge of the upward

ridge at a predetermined spacing to form the communication holes. (The tubes described will hereinafter be referred to as the "conventional technique 1"). The flat tube disclosed in the publication, FIGS. 5 and 6 is formed by bending an aluminum plate at the midportion of the width thereof to the shape of a hairpin and brazing opposite side edges of the plate to each other so as to form a hollow portion. The flat tube disclosed in FIG. 13 of the same publication is formed from a platelike upper component member and a platelike lower component member which are made of aluminum, by bending at least one of opposite side edges of each of the component members and brazing the two component members to each other at the opposite side edges thereof so as to form a hollow portion.

The above publication, FIG. 9 and FIGS. 12 to 14, discloses flat tubes each comprising an upper wall, a lower wall, a right and a left side wall interconnecting the upper and lower walls at the respective right and left side edges thereof, and a plurality of reinforcing walls interconnecting the upper and lower walls, extending longitudinally of the tube and spaced apart from one another as positioned between the right and left side walls, the tube having parallel fluid channels formed inside thereof, each of the reinforcing walls having communication holes for holding the adjacent fluid channels in communication with each other therethrough, each of the reinforcing walls being formed by brazing a ridge projecting inward from at least one of the upper and lower walls integrally

therewith to the inner surface of the flat other wall. Cutouts formed in the projecting edge of the ridge at a predetermined spacing have their openings closed with one of the upper and lower walls to form the communication holes. (The tubes of this type will hereinafter be referred to as the "conventional technique 2"). The flat tubes disclosed in the publication, FIGS. 9 and 12 are each formed by bending an aluminum plate at the midportion of the width thereof to the shape of a hairpin and brazing opposite side edges of the plate to each other so as to form a hollow portion. The flat tube disclosed in FIG. 14 of the same publication is formed from a platelike upper component member and a platelike lower component member which are made of aluminum, by bending at least one of opposite side edges of each of the component members and brazing the two component members to each other at the opposite side edges thereof so as to form a hollow portion.

However, the flat tubes of the conventional technique 1 are found to have the following problem. The communication holes in each reinforcing wall are formed by joining the cutouts formed in the lower edge of the downward ridge at a predetermined spacing to the respective cutouts formed in the upper edge of the upward ridge at a predetermined spacing, so that the downward ridge and the upward ridge are brazed at opposite sides of the cutouts. Consequently, the brazing material contributing to brazing is relatively small in quantity, and the brazed joint is relatively low in reliability and strength.

In the case of the flat tubes of the conventional technique 2, the communication holes in each reinforcing wall are formed by closing the openings of the cutouts provided in the projecting edge of the ridge at a predetermined spacing with one of the upper and lower walls, so that the problem of the conventional technique 1 can be solved. Nevertheless, to give a required height to the fluid channels and thereby ensure reduced flow resistance, the ridge needs to have a height greater than that of the downward ridge and the upward ridge of the flat tube of the conventional technique 1. This gives rise to a need to use an increased rolling load to be applied for making the aluminum plate or the platelike upper and lower component members by rolling. The increased rolling load can be applied generally by using rolling rolls of greater size, or using a satellite rolling mill comprising a center work roll and a plurality of planetary work rolls arranged around the center work roll and equidistantly spaced apart circumferentially thereof (see JP-A No. 141879/1998), or by using a multipass rolling mill. Any of these cases, nevertheless, results in the use of rolling equipment of greater size or an impaired production efficiency, entailing the problem of an increased manufacturing cost.

An object of the present invention is to overcome the foregoing problems and to provide a flat tube wherein ridges can be brazed with an increased strength for forming reinforcing walls and which is reduced in manufacturing cost, and a process for fabricating heat exchangers with use of such flat tubes.

DISCLOSURE OF THE INVENTION

The present invention provides a flat tube comprising an upper wall, a lower wall, a right and a left side wall interconnecting the upper and lower walls at respective right and left side edges thereof, and a plurality of reinforcing walls interconnecting the upper and lower walls, extending longitudinally of the tube and spaced apart from one another as positioned between the right and left side walls, the tube having parallel fluid channels formed inside thereof, each of the reinforcing walls having communication holes for holding the adjacent fluid channels in communication with each other therethrough, each of the reinforcing walls being formed from a downward ridge projecting downward from the upper wall integrally therewith and an upward ridge projecting upward from the lower wall integrally therewith by brazing the two ridges to each other, only one of the downward ridge and the upward ridge forming the reinforcing wall being provided with a plurality of cutouts arranged at a spacing longitudinally of the ridge, the cutouts having openings closed with the other ridge having no cutouts to thereby form the communication holes.

The flat tube of the prevent invention has reinforcing walls each formed from a downward ridge projecting downward from the upper wall integrally therewith and an upward ridge projecting upward from the lower wall integrally therewith by brazing the two ridges to each other, and only one of the

downward ridge and the upward ridge forming the reinforcing wall is provided with a plurality of cutouts arranged at a spacing longitudinally of the ridge. The openings of the cutouts are closed with the other ridge having no cutouts to thereby form the communication holes. Accordingly, when the outer or free end face of the ridge having no cutouts and forming the reinforcing wall has a brazing material applied thereto over the entire length thereof, the blazing material on each ridge portion having no cutout and opposed to the cutout of the other ridge of the wall flows in between the two ridges upon melting during brazing, with the result that the brazing material contributes to brazing in a larger quantity than in the conventional technique 1, giving improved reliability and enhanced strength to the brazed joint.

To form the reinforcing wall, the ridge projecting downward from the upper wall integrally therewith and the ridge projecting upward from the lower wall integrally therewith are brazed to each other, so that the height of these ridges can be made smaller than the ridges of the flat tube of the conventional technique 2. Use of rolling equipment of increased size for making the material for flat tubes and a reduction in production efficiency can therefore be avoided to result in a lower manufacturing cost.

The portions of a fluid flowing through the parallel fluid channels flow widthwise of the flat tube through the communication holes, thus spreading over the entire area of

all the fluid channels to become mixed together to achieve higher heat exchange efficiency. Especially in the case where refrigerant in a vapor phase and refrigerant in a liquid phase flow in the form of a mixture as in condensers or evaporators, the vapor phase and the liquid phase are effectively mixed together to attain a remarkably improved heat exchange efficiency.

The flat tube of the present invention satisfies the relationship of $H \leq 1.4$ mm, $h1 \leq 0.7$ mm and $h2 \leq 0.7$ mm wherein H is the height of the reinforcing wall, and h1 and h2 are the height of the downward ridge and the height of the upward ridge, respectively. The limitations of $h1 \leq 0.7$ mm and $h2 \leq 0.7$ mm are provided in view of the ease of rolling. Heights within this range are highly effective for the operation of rolling equipment of reduced size and for improving the production efficiency. Incidentally, the range of H is determined based on the values of h1 and h2. In this case, great advantages are attained in avoiding using rolling equipment of increased size or scale and preventing the reduction of operation efficiency.

Preferably, the heights H, h1 and h2 are in the ranges of:

$0.4\text{ mm} \leq H \leq 1.2\text{ mm}$, $0.2\text{ mm} \leq h1 \leq 0.6\text{ mm}$ and $0.2\text{ mm} \leq h2 \leq 0.6\text{ mm}$.

If H is less than 0.4 mm, the fluid channels become narrower to result in increased flow resistance and an impaired heat exchange efficiency when the tube is used as the heat exchange

tubes of heat exchangers. Further if H is in excess of 1.2 mm and when the tube is then used as heat exchange tubes of heat exchangers, the air flow clearance between the adjacent exchange tubes becomes too small to offer increased resistance to the flow of air and entail an impaired heat exchange efficiency. The ranges of h1 and h2 are determined according to the value of H. In this case, great advantages are attained in avoiding using rolling equipment of increased size or scale and preventing the reduction of operation efficiency. Moreover, the fluid channels are then given an optimum height, which reduces the tube in overall height, making the tube compact without entailing excessive flow resistance.

With the flat tube of the present invention, reinforcing walls having cutouts formed in the downward ridge and reinforcing walls having cutouts formed in the upward ridge are arranged alternately. Since reinforcing walls having cutouts formed in the downward ridge and reinforcing walls having cutouts formed in the upward ridge are arranged alternately, the portions of fluid flowing through the respective parallel fluid channels will flow zigzag upward and downward when flowing widthwise of the flat tube through the communication holes. This further enhances the above-mentioned effect to mix the whole fluid and to afford an improved heat exchange efficiency. Especially in the case where refrigerant in a vapor phase and refrigerant in a liquid phase flow in the form of a mixture as in condensers or evaporators, the vapor phase and the liquid phase are

effectively mixed together to attain a remarkably improved heat exchange efficiency.

With the flat tube of the present invention, the communication holes formed in all reinforcing walls may be in a staggered arrangement when seen from above. The portions of fluid flowing through the respective parallel fluid channels then flow widthwise of the flat tube through the communication holes. This produces an outstanding effect to spread the whole fluid over the entire area of all the fluid channels for further mixing.

The flat tube of the invention is 10 to 40% in opening ratio which is the ratio of all the communication holes in each reinforcing wall. The opening ratio is thus limited to 10 to 40% because if the ratio is less than 10%, the thermal conductance remains unincreased, whereas even if the ratio is in excess of 40%, the thermal conductance no longer increases, permitting an increase only in coefficient of friction. Increased thermal conductance available in the present case enables heat exchangers incorporating the flat tube of the invention to achieve an improved heat exchange efficiency.

The flat tube of the invention may be formed by bending a single metal plate at a midportion of width thereof and brazing opposite side edges thereof to each other so as to form a hollow portion. The metal plate can be bent to the shape of a hairpin, for example, by roll forming in this case, so that the tube can be produced by equipment of relatively

small scale.

In the case where the flat tube of the invention is formed by bending a single metal plate at a midportion of width thereof and brazing opposite side edges thereof to each other so as to form a hollow portion, the tube may be fabricated from a metal plate comprising a first portion and a second portion for forming the upper wall and the lower wall respectively which portions are made integral with each other by a joint portion, a third portion integral respectively with each of the first portion and the second portion and projecting upward from a side edge thereof opposite to the joint portion for forming one of the side walls, and a plurality of ridges projecting from each of the first portion and the second portion integrally therewith in the same direction as the third portion, by bending the metal plate at the joint portion to the shape of a hair pin, forming the upper and lower walls by the first portion and the second portion, forming the other side wall by the joint portion, forming said one side wall by brazing the third portions to each other end-to-end, and forming the reinforcing walls by brazing the ridges on one of the first and second portions to the respective ridges of the other of the first and second portions end-to-end. The metal plate can be bent to the shape of a hairpin, for example, by roll forming in this case, so that the tube can be fabricated by equipment of relatively small scale.

Preferably, the metal plate having the joint portion,

first portion, second portion, third portions and ridges is formed by rolling an aluminum brazing sheet, and the third portions and the ridges are formed on the surface of a brazing material of the brazing sheet integrally therewith. Since a brazing layer is formed on opposite side faces and the outer or free end faces of the third portions and the ridges, the brazing layer can be utilized for brazing the ridges end-to-end and the third portions to each other.

The flat tube of the invention may be formed by brazing a platelike upper component member of metal and a platelike lower component member of metal to each other in combination so as to form a hollow portion.

In the case where the flat tube of the invention is formed by brazing a upper component member of metal and a lower component member of metal to each other in combination so as to form a hollow portion, the upper component member has a first portion for forming the upper wall, second portions projecting downward from respective opposite side edges of the first portion integrally therewith for forming the side walls and a plurality of downward ridges projecting downward from the first portion integrally therewith, and the lower component member has a third portion for forming the lower wall, fourth portions projecting upward from respective opposite side edges of the third portion integrally therewith for forming the side walls and a plurality of upward ridges projecting upward from the third portion integrally therewith, the upper and lower walls

being formed respectively by the first portion and the third portion, each side wall being formed by brazing the second portion to the fourth portion, the reinforcing walls being formed by brazing the downward ridges to the upward ridges end-to-end.

Preferably, the upper component member and the lower component member are each formed by rolling an aluminum brazing sheet, and the second portions and the downward ridges, and the fourth portions and the upward ridges are formed on the surface of a brazing material of the brazing sheet integrally therewith. Since a brazing layer is formed on opposite side faces and the outer or free end faces of the second portions and the fourth portions, and the downward ridges and the upward ridges, the brazing layer can be utilized for brazing each second portion to the corresponding fourth portion and the ridges end-to-end.

The present invention provides a heat exchanger comprising a pair of headers arranged in parallel and spaced apart from each other, a plurality of parallel heat exchange tubes each comprising one of the flat tubes described above and each joined at opposite ends thereof to the two headers, fins each disposed in an air flow clearance between the adjacent heat exchange tubes and brazed to the adjacent tubes,

The present invention provides a process for producing a heat exchanger characterized by preparing a metal plate comprising a first portion and a second portion for forming

an upper wall and a lower wall respectively which portions are made integral with each other by a joint portion, a third portion integral respectively with each of the first portion and the second portion and projecting upward from a side edge thereof opposite to the joint portion for forming a side wall, and a plurality of ridges projecting from each of the first portion and the second portion integrally therewith in the same direction as the third portion and arranged widthwise of the metal plate at a spacing, the ridges of the first portion and the ridges of the second portion being positioned symmetrically about a center line of the metal plate with respect to the widthwise direction thereof; forming a plurality of cutouts in only one of the two ridges in each pair which are positioned symmetrically about the center line with respect to the widthwise direction, at a spacing longitudinally of the ridge; preparing a plurality of tacked bodies each by bending the metal plate to the shape of a hairpin at the joint portion to position the third portions end-to-end and the ridges end-to-end and temporarily holding the metal plate in the bent state; preparing a pair of headers each having tacked body inserting holes in the same number as the tacked bodies and a plurality of fins; arranging the pair of headers as spaced apart and arranging the tacked bodies and the fins alternately; inserting opposite ends of the tacked bodies into the holes of the headers; and simultaneously brazing the butting third portions of each tacked body to each other, the butting ridges

in each pair of each tacked body to each other, the tacked bodies to the headers, and each fin to the tacked bodies adjacent thereto.

In the process described above for producing a heat exchanger, ridges having the cutouts and ridges having no cutouts are provided alternately on the first portion of the metal plate, and ridges having the cutouts and ridges having no cutouts are provided alternately on the second portion of the metal plate.

The present invention provides another process for producing a heat exchanger characterized by preparing an upper component member having a first portion for forming an upper wall, second portions projecting downward from respective opposite side edges of the first portion integrally therewith for forming side walls and a plurality of downward ridges projecting downward from the first portion integrally therewith and arranged widthwise of the member at a spacing, and a lower component member having a third portion for forming a lower wall, fourth portions projecting upward from respective opposite side edges of the third portion integrally therewith for forming the side walls and a plurality of upward ridges projecting upward from the third portion integrally therewith and arranged widthwise of the lower component member at a spacing; forming a plurality of cutouts in only one of the downward ridge of the upper component member and the upward ridge of the lower component member positioned in corresponding relation with

the downward ridge in each pair, the cutouts being arranged at a spacing longitudinally of the ridge; preparing a plurality of tacked bodies each by fitting the upper and lower component members to each other with each of the second portions positioned in combination with the corresponding fourth portion and with the downward ridges and the upward ridges positioned end-to-end and temporarily holding the members as fitted to each other; preparing a pair of headers each having tacked body inserting holes in the same number as the tacked bodies and a plurality of fins; arranging the pair of headers as spaced apart and arranging the tacked bodies and the fins alternately; inserting opposite ends of the tacked bodies into the holes of the headers; and simultaneously brazing each second portion of each tacked body to the corresponding fourth portion thereof, the downward ridges of each tacked body to the upward ridges thereof, the tacked bodies to the headers, and each fin to the tacked bodies adjacent thereto.

In the process described above for producing a heat exchanger, downward ridges having the cutouts and downward ridges having no cutouts are provided alternately on the first portion of the upper component member, and upward ridges having the cutouts and upward ridges having no cutouts are similarly provided alternately on the third portion of the lower component member.

In a refrigeration cycle having a compressor, a condenser and an evaporator, the heat exchanger described above is used,

for example, as the condenser. The refrigeration cycle is installed in vehicles, for example, in motor vehicles.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary perspective view partly broken away and showing a flat tube of Embodiment 1 of the invention. FIG. 2 is a view in cross section of the same. FIG. 3 includes fragmentary perspective views showing a process for producing the flat tube of Embodiment 1 of the invention. FIG. 4 is a fragmentary perspective view partly broken away and showing a flat tube of Embodiment 2 of the invention. FIG. 5 is a view in cross section of the same. FIG. 6 includes fragmentary perspective views showing a process for producing the flat tube of Embodiment 2 of the invention. FIG. 7 is a perspective view showing a condenser for motor vehicle air conditioners.

BEST MODE OF CARRYING OUT THE INVENTION

Embodiments of the invention will be described below with reference to the drawings. Throughout the drawings, like parts are designated by like reference numerals and will not be described repeatedly.

Embodiment 1

This embodiment is shown in FIGS. 1 to 3.

FIGS. 1 and 2 show a flat tube according to this embodiment, and FIG. 3 shows a process for producing the flat tube.

With reference to FIGS. 1 and 2, the flat tube 1 is made

of aluminum and comprises flat upper and lower walls 2, 3, left and right side walls 4, 5 interconnecting the upper and lower walls 2, 3 at the respective left and right side edges thereof, and a plurality of reinforcing walls 6 interconnecting the upper and lower walls 2, 3, extending longitudinally of the tube and spaced apart from one another as positioned between the left and right side walls 4, 5. The tube has parallel fluid channels 7 formed inside thereof. Each of the reinforcing walls 6 has communication holes 8 for holding the adjacent fluid channels 7 in communication with each other therethrough. The flat tube is formed by bending a plate.

The reinforcing wall 6 is formed from a downward ridge 11 projecting downward from the upper wall 2 integrally therewith and an upward ridge 12 projecting upward from the lower wall 3 integrally therewith by brazing the two ridges to each other as positioned end-to-end. Only one of the downward ridge 11 and the upward ridge 12 forming each reinforcing wall 5 is provided with a plurality of cutouts 13 or 14 arranged at a spacing longitudinally of the ridge, and the cutouts 13 or 14 have their openings closed with the other ridge 11 or 12 having no cutouts, whereby the communication holes 8 are formed. According to the present embodiment, the reinforcing walls 6 having the cutouts 13 formed in the downward ridge 11 and reinforcing walls 6 having the cutouts 14 formed in the upward ridge 12 are arranged alternately. Thus, the reinforcing walls 6 having the communication holes 8 in its upper portion and

the reinforcing walls 6 having the communication holes 8 in its lower portion are arranged alternately. The communication holes 8 formed in the reinforcing walls 6 are in a staggered arrangement when seen from above.

Suppose the height of the reinforcing wall 6 is H, the height of the downward ridge 11 is h1, and the height of the upward ridge 12 is h2. The flat tube then satisfies preferably the relationships of $H \leq 1.4$ mm, $h1 \leq 0.7$ mm and $h2 \leq 0.7$ mm, more preferably the relationships of $0.4\ mm \leq H \leq 1.2$ mm, $0.2\ mm \leq h1 \leq 0.6$ mm and $0.2\ mm \leq h2 \leq 0.6$ mm.

The pitch of reinforcing walls 6 widthwise of the tube is preferably 0.5 to 2.5 mm. If the pitch is less than 0.5 mm, increased flow resistance will be offered, and it is likely that an increased number of reinforcing walls 6 will give increased weight to the tube when the tube has a definite width. Further if the pitch is in excess of 2.5 mm, a reduced heat transfer area will result, entailing the likelihood of the tube exhibiting a lower heat transfer efficiency when the tube is used as the heat exchange tube of heat exchangers.

The flat tube is 10 to 40%, preferably 10 to 30%, more preferably about 20%, in opening ratio which is the ratio of all the communication holes 8 in each reinforcing walls 6.

In a heat exchanger comprising such flat tubes 1 as heat exchange tubes, portions of a fluid flowing through the parallel fluid channels 7 flow widthwise of the flat tube 1 through the communication holes 8 and spread through all the holes

8 to become mixed together. Since the reinforcing walls 6 having cutouts 13 formed in downward ridges 11 and the reinforcing walls 6 having cutouts 14 formed in upward ridges 12 are arranged alternately, the fluid flows zigzag upward and downward when flowing through the communication holes 8 widthwise of the tube 1 (see arrows in FIG. 2). This achieved an improved heat exchange efficiency. Especially in the case where refrigerant in a vapor phase and refrigerant in a liquid phase flow as mixed together as in condensers or evaporators, the above feature mixes the vapor phase and the liquid phase more effectively to attain a remarkable improvement in heat exchange efficiency.

The flat tube 1 is fabricated by the process illustrated in FIG. 3.

First, an aluminum brazing sheet clad with a brazing material over opposite surfaces is passed between rolling rolls to make a metal plate 15 shown in FIG. 3(a) for producing a flat tube. The metal sheet 15 comprises a flat first portion 17 and a flat second portion 18 for forming an upper wall 2 and a lower wall 3, respectively, which portions are made integral with each other by a flat joint portion 16, third portions 9, 10 integral respectively with the first portion 17 and the second portion 18 and each projecting upward from a side edge thereof opposite to the joint portion 16 for forming a left side wall 4, and a plurality of ridges 11 or 12 upwardly projecting from each of the first portion 17 and the second portion 18 integrally therewith and arranged widthwise of

the metal plate at a spacing. The ridges 11 on the first portion 17 and the ridges 12 on the second portion 18 are positioned symmetrically about a center line of the metal plate with respect to the widthwise direction thereof. Since the third portions 9, 10 and the ridges 11, 12 are formed on one surface of the aluminum brazing sheet clad with the brazing material over opposite surfaces, a brazing layer (not shown) is formed on opposite side faces and the upper end faces of the third portions 9, 10 and the ridges 11, 12 and on the upper and lower surfaces of the first and second portions 17, 18. The brazing layer on the upper end faces of the third portions 9, 10 and the ridges 11, 12 has a larger thickness than the brazing layer on the other portions. Only one of the two ridges 11, 12 in each pair which are positioned symmetrically about the center line with respect to the widthwise direction is provided with a plurality of cutouts 13, 14 at a spacing longitudinally of the ridge. According to the present embodiment, the ridges 11, 12 provided with cutouts 13, 14 and the ridges 11, 12 provided with no cutouts are formed alternately on the first portion 17 and the second portion 12. The corresponding cutouts 13 in the ridges 11 of the first portion 17 are in the same position longitudinally of the ridge. Similarly, the corresponding cutouts 14 in the ridges 12 of the second portion 18 are in the same position longitudinally of the ridge, but are shifted from those 13 of the first portion 17 longitudinally of the ridge.

Subsequently, the metal plate 15 is bent to a V-shape at the left and right side edges of the joint portion 16 by the roll forming process [see FIG. 3(b)], and is further bent to the shape of a hairpin to position the third portions 9, 10, as well as the ridges 11, 12, end-to-end and obtain a bent body 19 [see FIG. 3(c)]. At this time, a right side wall 5 is formed by the joint portion 16, an upper wall 2 by the first portion 17 and a lower wall 3 by the second portion 18.

The bent body 19 is thereafter heated at a predetermined temperature to braze the third portions 9, 10 to each other and the two ridges 11, 12 in each pair to each other end-to-end and form a left side wall 4 and each reinforcing wall 6. In this way, the flat tube 1 is fabricated.

When such flat tubes 1 are to be used, for example, as the refrigerant tubes 52 of the condenser shown in FIG. 7, the flat tubes 1 may be produced simultaneously with the fabrication of the condenser. Stated more specifically, the condenser is fabricated in the following manner. First, a plurality of bent bodies 19 as shown in FIG. 3(c) are prepared from metal plates 15 which are made in the same manner as above, and the bodies are temporarily held as bent by a suitable method. Further prepared are a pair of headers 50, 51 each having bent body inserting holes in the same number as the tacked bent bodies 19 and a plurality of corrugated fins 53. The pair of headers 50, 51 are then arranged as spaced apart, the bent bodies 19 and the fins 53 are arranged alternately,

and opposite ends of the bent bodies 19 are inserted into the holes of the headers 50, 51. The resulting assembly is thereafter heated at a predetermined temperature to simultaneously braze the third portions 9, 10 of each bent body 19 to each other, the butting ridges 11, 12 in each pair of each body to each other, the bent bodies 19 to the headers 50, 51, and each corrugated fin 53 to the bent bodies 19 adjacent thereto, utilizing the brazing material layer of each metal plate 15. The condenser is fabricated in this way.

Embodiment 2

This embodiment is shown in FIGS. 4 to 6.

FIGS. 4 and 5 show a flat tube according to this embodiment, and FIG. 6 shows a process for producing the flat tube.

With reference to FIGS. 4 and 5 showing the flat tube 20, left and right side walls 21, 22 interconnecting flat upper and lower walls 2, 3 at the respective left and right side edges thereof each have a double wall structure, and the flat tube 20 is formed by brazing a platelike upper component member 23 of aluminum and a platelike lower component member 24 of aluminum to each other in combination so as to form a hollow portion. With the exception of these features, the flat tube 20 has the same construction as the flat tube 1 according to Embodiment 1.

The flat tube 20 is fabricated by the process shown in FIG. 6.

First, an aluminum brazing sheet clad with a brazing

material over opposite surfaces is passed between rolling rolls to make the upper component member 23 and lower component member 24 as shown in FIG. 6(a). The upper component member 23 comprises a flat first portion 31 for forming the upper wall 2, second portions 25, 26 projecting downward from the respective opposite side edges of the first portion 31 integrally therewith for forming the side walls 21, 22 and a plurality of downward ridges 11 projecting downward from the first portion 31 integrally therewith and arranged at a spacing widthwise of the member 23. The upper surface of the first portion 31 has a slope 29 at each of the left and right side edges thereof. The lower component member 24 comprises a flat third portion 32 for forming the lower wall 3, fourth portions 27, 28 projecting upward from the respective opposite side edges of the third portion 32 integrally therewith for forming the side walls 21, 22 and a plurality of upward ridges 12 projecting upward from the third portion 32 integrally therewith and positioned in corresponding relation with the respective downward ridges 11 of the first portion 31. The fourth portions 27, 28 of the lower component member 24 have a greater height than the second portions 25, 26 of the upper component member 23. Since an aluminum brazing sheet clad with the brazing material over opposite surfaces is used for making the upper and lower component members 23, 24, the second portions 25, 26, the fourth portions 27, 28, the downward ridges 11 and the upward ridges 12 are formed on one surface of the brazing sheet integrally

therewith. A brazing layer (not shown) is formed on opposite side faces and the outer or free end faces of the second portions 25, 26, the fourth portions 27, 28 and the ridges 11, 12 and on the upper and lower surfaces of the first and third portions 31, 32. The brazing layer on the outer or free end faces of the second portions 25, 26, the fourth portions 27, 28 and the ridges 11, 12 has a larger thickness than the brazing layer on the other portions. Only one of the ridges 11, 12 in each pair, i.e., the downward ridge 11 of the upper component member 23 and the upward ridge 12 of the lower component member 24 positioned in corresponding relation with the ridge 11, is provided with a plurality of cutouts 13, 14 at a spacing longitudinally of the ridge. According to the present embodiment, downward ridges 11 having the cutouts 13 and downward ridges 11 having no cutouts are provided alternately on the first portion 31 of the upper component member 23, and upward ridges 12 having the cutouts 14 and upward ridges 12 having no cutouts are similarly provided alternately on the third portion 32 of the lower component member 24. The corresponding cutouts 13 in the ridges 11 of the first portion 31 are in the same position longitudinally of the ridge. Similarly, the corresponding cutouts 14 in the ridges 12 of the third portion 32 are in the same position longitudinally of the ridge, but are shifted from those 13 of the first portion 31 longitudinally of the ridge.

Subsequently, the upper and lower component members 23,

24 are fitted to each other in combination so that the upwardly projecting fourth portions 27, 28 of the lower component member 24 are lapped over the respective downwardly projecting second portions 25, 26 of the upper component member 23, with the downward ridges 11 positioned on the respective upward ridges 12 end-to-end. The upper ends of the fourth portions 27, 28 of the lower component member 24 are inwardly bent leftward or rightward to temporarily hold the members 23, 24 fitted to each other to obtain a tacked body 33 [see FIG. 6(b)]. At this time, the upper wall 2 is provided by the first portion 31, and the lower wall 3 by the third portion 32.

The tacked body 33 is thereafter heated at a predetermined temperature to braze each second portion 25 (26) to the corresponding fourth portion 27 (28) and the ridges 11 to the respective ridges 12 in corresponding relation, utilizing the brazing material layer, and braze the bent parts of the fourth portions 27, 28 to the respective slopes 29, whereby the left and right side walls 21, 22 and the reinforcing walls 6 are formed. In this way, the flat tube 20 is fabricated.

When such flat tubes 20 are to be used, for example, as the refrigerant tubes 52 of the condenser shown in FIG. 7, the flat tubes 20 may be produced simultaneously with the fabrication of the condenser. Stated more specifically, the condenser is fabricated in the following manner. First, a plurality of tacked bodies 33 as shown in FIG. 6(b) are prepared in the manner described above. Further prepared are a pair

of headers 50, 51 each having tacked body inserting holes in the same number as the tacked bodies 33, and a plurality of corrugated fins 53. The pair of headers 50, 51 are then arranged as spaced apart, the tacked bodies 33 and the fins 53 are arranged alternately, and opposite ends of the tacked bodies 33 are inserted into the holes of the headers 50, 51. The resulting assembly is thereafter heated at a predetermined temperature to simultaneously braze the second portions 25, 26 of each tacked body 33 to the respective fourth portions 27, 28 thereof, the butting ridges 11, 12 in each pair of each body to each other, the tacked bodies 33 to the headers 50, 51, and each corrugated fin 53 to the tacked bodies 33 adjacent thereto, utilizing the brazing material layer of the upper and lower component members 23, 24. The condenser is fabricated in this way.

The heat exchanger comprising the flat tube 1 or 20 of Embodiment 1 or 2 is useful for vehicles, e.g., motor vehicles, comprising a refrigeration cycle having a compressor, a condenser and an evaporator, as the condenser of the refrigeration cycle. The heat exchanger is useful also as the evaporator of the refrigeration cycle. The heat exchanger will also be installed in motor vehicles as an oil cooler or radiator.

INDUSTRIAL APPLICABILITY

The flat tube of the invention is suitable for use as heat exchange tubes for heat exchangers, for example, for use

as refrigerant tubes in condensers or evaporators for motor vehicle air conditioners, as oil tubes in motor vehicle oil coolers and as water tubes in motor vehicle radiators.